	Type	L #	Hits	Search Text	DBs	Time Stamp	Comments	Error Definition	Errors
1	BRS	L1	30	(FIB or "focused ion beam") same etch$3 same ("O.sub.2" or "nitrous oxide" or "N.sub.2 O" or "O.sub.3" or ozone or O2 or O3 or N2O)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/03/07 17:51			0
2	BRS	L8	0	(FIB or "focused ion beam") same etch$3 same ("O.sub.2" or "nitrous oxide" or "N.sub.2 O" or "O.sub.3" or ozone or O2 or O3 or N2O) same (Cu or copper)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/03/07 16:01			0
3	BRS	L15	6	(FIB or "focused ion beam") and etch$3 same ("O.sub.2" or "nitrous oxide" or "N.sub.2 O" or "O.sub.3" or ozone or O2 or O3 or N2O) same (Cu or copper)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/03/07 16:41			0
4	BRS	L22	139	(FIB or "focused ion beam") and etch$3 and ("O.sub.2" or "nitrous oxide" or "N.sub.2 O" or "O.sub.3" or ozone or O2 or O3 or N2O) and (Cu or copper)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/03/07 17:05			0
5	BRS	L29	19	22 and 216/$.ccls.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/03/07 17:06			0
6	BRS	L36	8	(FIB or "focused ion beam") with etch$3 with ("O.sub.2" or "nitrous oxide" or "N.sub.2 O" or "O.sub.3" or ozone or O2 or O3 or N2O)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/03/07 17:57			0

US-PAT-NO: 5580419

DOCUMENT-IDENTIFIER: US 5580419 A

TITLE: Process of making semiconductor device using focused ion beam for resistless in situ etching, deposition, and nucleation

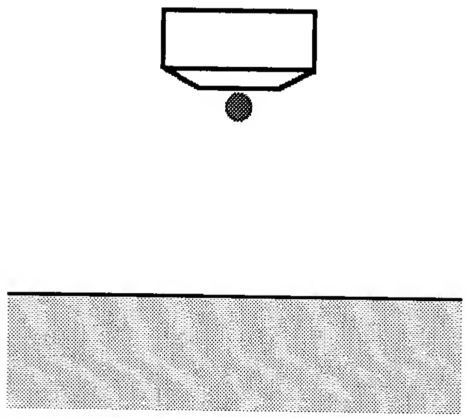
---------- KWIC ---------

Turning to FIG. 4, the recess **etch** process which is one of the core processes for the manufacture of **integrated circuits,** is shown in detail for producing a GaAs metal semiconductor field effect transistor (MESFET). The advanced ion beam processing system 10 creates the recess **etch** by utilizing a two-step batch
process involving the **focused ion beam** column 18 and the IBACE chamber 42. This two-step batch process is conducted after an oxide layer 52 consisting of gallium and arsenic oxide and having a thickness of about 30 angstroms is grown
over the entire wafer 22 in the oxidation chamber 50 with **ozone** plasma. Thereafter, a low dose 10 KeV Ga.sup.+ **focused ion beam** 20 is selectively patterned along the oxide layer 52 creating a three-dimension damaged implant region 54. The wafer 22 containing this region 54 is then inserted into the IBACE chamber 42 with the mechanical arm 40 and heated to between about 100.degree. C. to 200.degree. C. Once heated, a volatile gas, preferably chlorine gas (Cl.sub.2) is pumped into the IBACE chamber 42 which reacts with the region 54. This causes the release of gallium chloride (GaCl.sub.2) and arsenide chloride (AsCl.sub.2) bi-products to create a recess **etch** 56 where the **focused ion beam** 20 was previously patterned.

Integrated Reliability

A focused ion beam workstation (FIB) operates similar to a scanning electron microscope (SEM) in that both instruments take charged particles from a source, focus them into a beam through electromagnetic/electrostatic lenses, and then scan across small areas of the sample using deflection plates or scan coils.

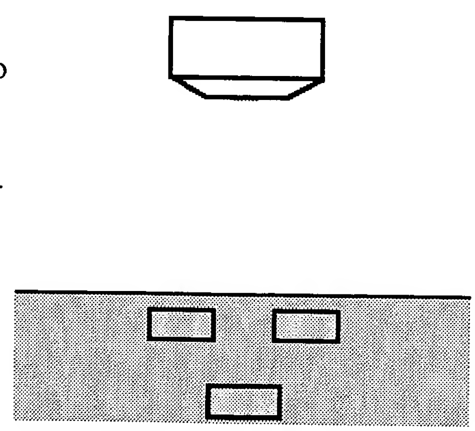
Both instruments are used for high resolution imaging by collecting the secondary electron emission produced by the beam's interaction with the sample surface. Contrast is formed by raised areas of the sample (hills) producing more secondary electrons than depressed areas (valleys). A viewing CRT is synched to the scan coils controlling the beam so as the beam scans across the sample surface, its image is reproduced on the screen.

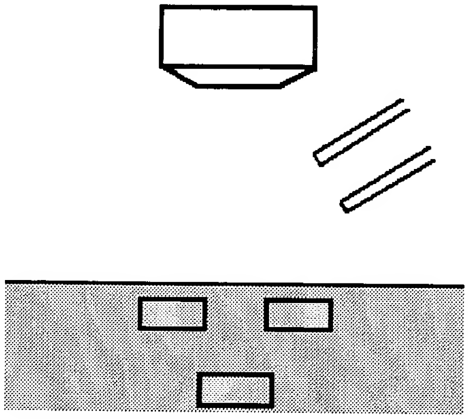


Where a FIB differs from an electron microscope is that instead of using electrons to form its imaging beam, the FIB uses gallium ions from a field emission liquid metal ion (FE-LMI) source. Within reasonable beam currents an electron beam is nondestructive, but since gallium ions are orders of magnitude more massive than electrons, a FIB's ion beam mills the sample surface as it images it. With its computer controlled 5 axis stage, a focused ion beam workstation is, in effect, a CNC milling machine on a micro scale.

Unfortunately, an ion beam will not etch through unlimited thicknesses of material. Depending on such variables as sample composition, mill area, beam parameters, and whether an enhanced etch process is used, the maximum aspect ratio of a FIB milled hole varies from ~3:1 to greater than 10:1.

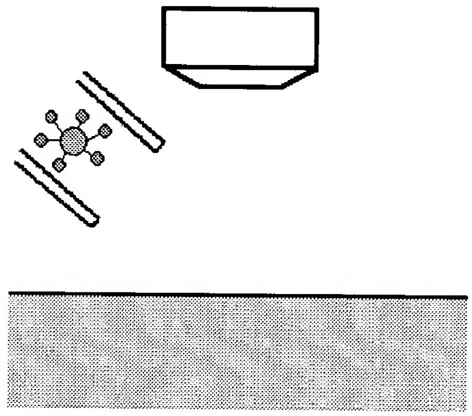
Here, the ion beam is used to mill through an integrated circuit's top two layers of passivation and Metal 2 (top) layer of metallization to expose a Metal 1 (Bottom) metallization line.





But by injecting a reactive gas into the mill process, the aspect ratio of the ion beam's cutting depth can be dramatically altered such that it is possible to reach the lower metallization line without disturbing the upper layer metallization. Two typical gasses are iodine and xenon difluoride.

A focused ion beam can also be used to deposit material. Some organic and organometallic compounds have high enough vapor pressures that they may be injected as a gas into the vacuum chamber where they are adsorbed onto the sample surface. Here, a platinum organometallic molecule is being injected. When this precursor molecule is struck by either the incident gallium ion beam or by secondary emission products (phonons), the chemical bonds holding it together break, releasing the carbon atoms into the FIB's vacuum chamber. The heavier platinum atom is then deposited as an electrical conductor onto the sample surface. The deposition process or other materials is similar. For example, silicon rich insulating films can be deposited using organosilane precursors.

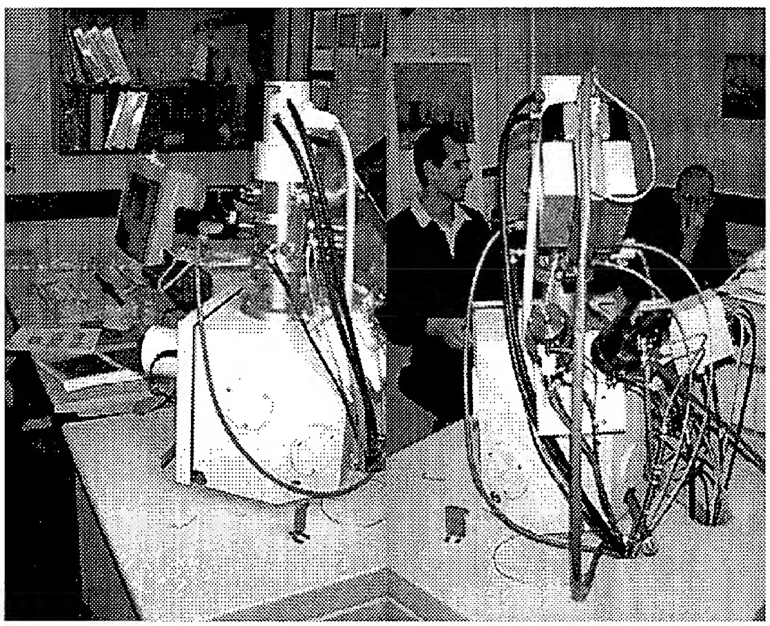


Using these two methods of surface milling and deposition, a focused ion beam becomes a powerful tool in IC design by allowing circuitry modifications to be performed at the prototype stage. To see an example of a circuit modification, click on the "next" below.

< Services | Equipment | Data &Reports | Information | Home | Next >

Focused ion beam processing of materials

A focused ion beam (FIB) system is similar to a scanning electron microscope, except that instead of using an electron beam, a beam of ions is scanned across the sample. The ion beam is ejected from a liquid metal ion source (usually Ga), with a spot size on modern systems of <10nm. Imaging using secondary electrons provides surface information with similar resolution to that obtainable from an SEM; however the main applications arise from the use of ions as the scanned species. These include compositional imaging via secondary ions, direct etching of material in selected regions for in-situ sectioning and imaging, microfabrication, transmission electron microscopy specimen preparation, and localised deposition and implantation of metal and insulator structures. Follow this link for a useful page describing some of these applications. Our main application is in nanofabrication of devices. The unique combination of 10 nm resolution imaging with the ability both to remove and to deposit material in selected areas provides a means of performing materials studies or device fabrication processes which would otherwise be impossible or unreasonably time-consuming. We operate a FEI FIB 200 system funded largely by the UK Engineering and Physical Sciences Research Council.



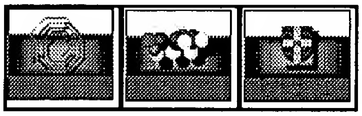
The Department has a number of on-going programmes based round ion beam processing:

- Micromachining
- Electron microscopy specimen preparation
- Imaging
- Device processing (80k pdf file)
- Nanofabrication

Operation Information

- Authorised Users

- Booking instructions
- FIB user instructions
- Implantation Depths
- Labview software
- Pt Deposition



Pages constructed by:
Mark Blamire
Dept. Materials Science and Metallurgy, University of Cambridge,
Pembroke Street, Cambridge CB2 3QZ, UK